Eating our Seed Corn

Peter J. Denning

This is the text of the ACM President's Letter for the *Communications of ACM*, June 1981.

Much has been written within the computing community about the manpower shortage. In 1979, the Feldman Report outlined the benefits to our field from university-based computer science research over the years.[1] In 1980, the Computer Science Board released the Snowbird Report, which outlined the specific problems facing computer science departments in the United States and Canada because of severe faculty shortages.[2] Both reports cite underfunding as the force pulling computer science to the brink. Both note the irony that the institutes that train personnel for the prosperous computer field are not themselves prosperous.

The message of the Feldman Report can be summed up by: "Don't kill the goose that lays the golden eggs." The message of the Snowbird Report can be summed up: "We are eating our seed corn."

Although they have attracted much attention and stimulated much discussion, both reports have been criticized. Skeptics allege that the "crisis" is manufactured to help win an unfair share of scarce resources for computer science while it rides a wave of popularity; that the reports are based on anecdotes, not facts; and that shortages will be corrected by the marketplace.

Some Facts

From 1975 to 1981, undergraduate majors in Computer Science doubled. (At Purdue, for example, there were 430 majors in 1975 and 1000 by fall 1981.) The National Center for Educational Statistics projects another 60 percent growth

[1] See "Rejuvenating Experimental Computer Science -- A report to the National Science Foundation and Others," *Communications of ACM*, September 1979, 497-502.

[2] "The Snowbird Report: A Discipline in Crisis," a statement from the 56 Computer Science Department heads who met at Snowbird, Utah, in July 1980. See *Communications of ACM*, June 1981, 370-374.

by 1987.[3] One might expect a corresponding jump in faculty as universities respond to the demand.

On behalf of the Computer Science Board, O. Taulbee and S. D. Conte conduct an annual survey of all departments in the United States that grant PhD's in Computer Science. Table 1 shows the production pf PhDs from these departments and also the number of PhD-holding faculty employed by these departments.[4] Taulbee and Conte report that approximately 45 percent of each graduating group of PhDs selected academic positions. Therefore, one intuitively expects that about 500 of the 1127 PhDs graduated in 1974-78 would add to faculty ranks during 1975-79. This has not happened.

Table 1: US Computer Science PhD Production and Faculty (1973-80)

Year	No. PhDs Granted in Computer Science	No. Faculty Holding PhDs	Total No. Faculty
1973	208	n/a	n/a
1974	203	787	862
1975	256	805	878
1976	246	773	843
1977	208	790	881
1978	214	825	938
1979	248	837	958
1980	265	n/a	n/a

What has happened is striking: a net increase of only 32 PhD faculty during 1975-79. The exodus from university to industry is so great that PhD faculty have grown by only 2.8 percent of the number of new PhDs taking academic positions. Unable to find teachers, some universities are forced to cut enrollments and limit class size in computer science.[5]

In 1975 there were 60 PhD-granting departments in the United States; by 1980 there were 77. Table 2 shows that the growth in departments has not been accompanied by growth in PhD production or faculty per department. The new departments have not yet built up their faculty or PhD programs.

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[3] J. Margarrell, "As students flock to computer science courses, colleges scramble to find professors," *The Chronicle of Higher Education*, February 9, 1981, page 3. This article contains a considerable amount of data about the problem.

[4] Most of these data are taken from "Production and Employment of PhDs in Computer Science -- 1977 and 1978," *Communications of ACM*, February 1979, pages 75ff. The rest are taken from update reports circulated among department chairmen.

[5] B. Schultz, "Short on teachers, school cutting enrollments, *Computerworld*, March 23, 1981, page 9.

Table 2: PhDs and Faculty per US Computer Science Department.

Year	No. Depts.	PhDs per Dept.	Faculty per Dept.
1975	60	4.3	14.6
1979	77	3.2	12.4

NSF is completing a faculty mobility study among the PhD-granting departments. Preliminary data show that 53 departments reporting had an average of 1.8 replacement positions and another 1.8 new positions to fill during 1979-80 recruiting. Each department filled an average of 2.5 of its 3.6 open positions. The average department was trying to increase its faculty from 14.2 to 16.0 members; these departments were therefore about 11 percent below authorized strength.

In the January 1981 issue of *Communications,* I counted employment ads from 143 university departments in the United States and Canada who seek PhDs in Computer Science. Each ad gives a lower bound on the number of open positions. The sum of these lower bounds is, by my count, 273 open positions. If 45 percent of the PhDs estimated for 1981 take university positions (in the current market this figure is optimistic), there will remain at least 150 open positions.

At the ACM Computer Science Conference in St. Louis (February 1981), the ratio of PhD-requiring positions listed in the Employment Register to PhD-holding applicants was 34:1. At the BS level the ratio was 12:1. Although hardly unbiased, these figures reflect the general conditions of the market.

These changes have put great pressure on salaries. In 1980, average industry starting salaries were about $20K at the BS level, $24K at the MS level, and $32K at the PhD level. Early indications are that these numbers may jump by another 10-20 percent again this year. By comparison, the average offer to a new PhD for a nine-month academic position in 1980 was about $22K. There is clearly little incentive for BS holders to contemplate graduate school when their current offers are comparable to those paid the newest faculty.

A National Problem

Mounting evidence from all quarters shows that the computer science problem is a piece of a larger national problem that seriously threatens the foundations of higher education in science and technology. It is caused by the

blurring of the traditional distinction between university research and industrial research.[6]

In October 1980 the National Science Foundation released a report commissioned by President Carter, called Science and *Engineering Education in the 1980s and Beyond*. This report reached two conclusions: First, there is a severe manpower problem in most disciplines of science and technology, with computer science and engineering being the worst affected. Second, there is growing scientific illiteracy among our young people, who must eventually make decisions that require technological understanding.

The NSF-ED report cited figures from the Bureau of Labor Statistics showing that the manpower shortages are widespread and real. Although many are "spot shortages" that will clear up by "marketplace adjustments" by 1990, the shortages in the computing field are fundamental and likely will persist well into the next decade. The report considers this ominous: Universities will not be able to expand educational capacity or maintain quality as demanded in the marketplace. Some experts think matters will be worse than these projections because they universities do not operate inside the "free market"; most cannot respond to market conditions by increasing salaries and laboratory facilities without protracted political battles in the state legislatures that set their budgets.

In November 1980 *Business Week* published an articled called "How Industry is Draining University Sciences."[7] Citing data from the NSF, this article pointed out a decline of 25 percent in doctorates in Physical Sciences and Engineering -- from about 9200 ini 1971 to about 6800 in 1979. This drop occurs during a period of increasing need for teachers and for researchers. To illustrate that there is no surge of students in the pipeline, the article noted that 69 percent of Cornell graduates chose employment over graduate school in 1980, as compared with 32 percent in 1975. It states that engineering faculties nationally are about 15 percent below authorized strength. It states bluntly that "industry is eating some of its own seed corn. Not only are they taking students who would become faculty, they are recruiting faculty."

A recent article in the Sunday *New York Times* blamed the obsolescent laboratory facilities and low faculty salaries for the problem. Similar statements have appeared in short articles in international publications like *Newsweek*, *US News and World Report*, and the *London Times*.

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[6] S. Pogrow, "In an information economy, universities and business compete for workers." *The Chronicle of Higher Education*, March 16, 1981, page 64.
[7] *Business Week*, November 17, 1980, pages 170Dff.

Quality Threatened

The Snowbird Report and the NSF-ED report both make the point that the working environment may not be able to sustain quality: Lab and computing facilities are not being upgraded or expanded to meet the demand; salaries and graduate student stipends are unattractive; faculties have not grown; heavy time commitments to large classes and counseling destroy the intellectual and deprive graduate students of proper supervision. The output of this system is coming under criticism.[8] The system itself illustrates the classic vicious circle.

W(h)ither We?

Are the skeptics right? Is the crisis imagined? Will the marketplace correct it? Abundant data show the crisis is not manufactured. It is chronicled not only in the journals of the professional societies, but in many national magazines widely read by industry. The phrase "eating our seed corn" appears everywhere. Without changes in government policy, most universities will remain outside the free marketplace.

Is anyone doing anything about it? So far, there is mostly talk. The Computer Science and Technology Board of the National Research Council plans a workshop to investigate whether there is a shortage and, if so, what its causes might be. I sincerely hope we can soon disengage ourselves from study mode.

At a meeting on March 6, 1981, with executives of scientific and engineering societies, I asked Congressman George Brown about this problem. He said that witnesses bring it up all the time; members of the Science and Technology Subcommittee are well aware of it. On the other hand, there is in Congress sentiment that "all the universities must do is raise faculty salaries," and the problem will go away. I judge it unlikely that Congress will do anything.

At the same meeting an aide of President Reagan stated the new administration aims to simulate capital formation, which will in turn help research and development. The new administration believes its policy will help science and technology in the long term. It asserts it *is* already doing something to help.

What worries me is whether we can survive the transition from the current conditions to the new ones foreseen by the government. As Federal budgets

[8] J. Beeler, "Mediocrity blamed on programmer shortages," *Computerworld*, March 23, 1981, page 8.

are cut, the states will be forced to pay for entitlement programs. Even if the economy improves, the states will be under considerable financial pressure for the next few years. Universities will not have an easy time persuading legislatures to be more competitive with industry in salaries and facilities. In the end, industrial friends of universities must help persuade the state legislatures, who regard apocalyptic statements as self-serving when uttered by presidents of universities or scientific societies.

More political battles over the salary problem await universities internally. Faculty in disciplines not sought actively by the marketplace resist raising of salaries in other disciplines on the grounds that all work equally hard for the university. The universities face, and solved, this problem some years ago with the medical schools. It is now time to deal with it in science and engineering schools.

The main hope is that new coalitions will open up rapidly between industry and university. Otherwise, the fertile ground from which industry has harvested rich crops of well trained scientists and engineers will blow away on dry winds.

The difficulties notwithstanding, there are many dedicated people who *enjoy* teaching and supervising graduate students. For almost exclusively in universities is it possible to pursue basic research in the public domain -- free of the constraints of immediate commercial application and trade secrecy -- and thereby add to the store of ideas saved for the long-term future.

Note Added Later:

I cite the following paragraph from Kent Curtis's 1982 NSF report on "Computer Manpower -- Is There a Crisis?":

> Let us consider the conundrum facing the computer field in higher education first. It is experiencing an exponentially increasing demand for its product with an inelastic labor supply. How has it reacted? NSF has made a survey of the responses of engineering departments, including computer science departments in schools of engineering, to the increasing demand for undergraduate education in engineering. There is a consistent pattern in their responses and the results can be applied without exception to the computer field whether the departments are located in engineering schools or elsewhere. 80% of the universities are responding by increasing teaching loads, 50% by decreasing course offerings and concentrating their available faculty on larger but fewer courses, and 66% are using more graduate-student teaching assistants or part-time faculty. 35% report reduced research opportunities for faculty as a result. In brief, they are using a combination of rational management measures to adjust as well as they can to the severe manpower constraints under which they must operate. However, these measures make the universities' environments less attractive for employment and are exactly counterproductive to their need to maintain and expand their labor supply. They are also counterproductive to producing more new faculty since the image graduate students get of academic careers is one of harassment, frustration, and too few rewards. The universities are truly being choked by demand for their own product and have a formidable people-flow problem, analogous to but much more difficult to address than the cash-flow problem which often afflicts rapidly growing businesses. There are no manpower banks which can provide credit.

This showed little amelioration of the problem a year after my commentary and it showed the departments making a gallant effort to accommodate the rising demand.